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U. S. DEPARTMENT OF AGRICULTURE.

FOREST SERVICE—BULLETIN No. 65.

GIFFORD PINCHOT, Forester.

ADVICE

FOR

FOREST PLANTERS

IN

OKLAHOMA AND ADJACENT REGIONS.

By

GEORGE L. CLOTHIER, M. F.,

ASSISTANT FOREST INSPECTOR, FOREST SERVICE.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1905.

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Fort Collins CO 80526

Lowlands Belt | Cross timbers Belt | Red beds Belt | Plains Belt

(X-21.55) X = Average of 10 years. 21.55 = Average annual rainfall of 21.55 inches

MAP SHOWING SILVICAL BELTS AND RAINFALL.

RECORDS OF RAINFALL

ANDREW B. GRAHAM CO., PHOTO-LITHOGRAPHERS, WASHINGTON, D. C.

U. S. DEPARTMENT OF AGRICULTURE,
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LETTER OF TRANSMITTAL.

DEPARTMENT OF AGRICULTURE,
BUREAU OF FORESTRY,
Washington, D. C., June 21, 1905.

SIR: I have the honor to transmit herewith a report entitled "Advice for Forest Planters in Oklahoma and Adjacent Regions," by George L. Clothier, Assistant Forest Inspector, Forest Service, and to recommend its publication as Bulletin No. 65 of the Forest Service.

The map, four plates, and seven text figures accompanying the report are necessary for its proper illustration.

Very respectfully,

GIFFORD PINCHOT,
Forester.

HON. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

	Page.
The region	7
Forest supporting capacity of the region	7
The ability of the region to support forests	8
The care of forest plantations on the prairies and plains	9
Treatment of the soil	9
Mulching	9
Spacing the trees	10
Situations where cultivation is unnecessary	10
Fall cultivation harmful	10
Tools—Methods of cultivation	11
Grazing—Fire	11
Setting out trees	12
The proper season	12
Heeling in	13
Planting deciduous trees	14
Planting by horsepower	14
Treatment of evergreen trees	15
Planting plan suited to the Lowlands Belt	16
Planting plan for a demonstration area in the Lowlands Belt	19
Planting plan suited to the Cross Timbers Belt	23
Plan for a commercial plantation in the Red Beds Belt	25
Another planting plan suited to the Red Beds Belt	28
Model planting plan for prairie farms in Oklahoma	31
Model planting plan for the plains of eastern New Mexico and western Texas	36
Trees mentioned in this report	40
Shrubs useful for planting in this region	41
Index	43

ILLUSTRATIONS.

MAP.

Page.

Map showing silvical belts and rainfall ..... Frontispiece.

PLATES.

PLATE I. Fig. 1.—A "lister" double moldboard plow making shallow furrows for planting locust seed. Fig. 2.—Planting forest trees in lister furrows on the semiarid plains 16

II. Fig. 1.—A portable sawmill converting into lumber cottonwood logs from planted trees 15 years old, Kingman County, Kans. Fig. 2.—Locust on an abandoned "tree claim" in southwestern Kansas 16

III. Fig. 1.—Locust and hardy catalpa in mixture, eastern Kansas. Fig. 2.—Green ash 4 years old, Staked Plains of Texas 32

IV. Plantation on the Staked Plains of Texas, made according to planting plan No. 37: Fig. 1.—Locust 5 years old in foreground; white elm in background. Fig. 2.—Locust 5 years old; cultivation between rows neglected 32

TEXT FIGURES.

FIG. 1. Heeling in young trees 13

2. Planting plan for the Lowlands Belt 17

3. Planting plan for a demonstration area in the Lowlands Belt 21

4. Plan for a commercial plantation in the Red Beds Belt 26

5. Another plan for the Red Beds Belt 29

6. Model planting plan for a prairie farm 32

7. Model planting plan for the plains of eastern New Mexico and western Texas 37

ADVICE FOR FOREST PLANTERS IN OKLAHOMA AND ADJACENT REGIONS.

THE REGION.

The region to which this publication is devoted lies between the thirty-third and thirty-eighth parallels and the ninety-sixth and one hundred and fourth meridians, and embraces approximately 160,000 square miles. It includes all of Oklahoma and portions of Indian Territory, Kansas, Colorado, Texas, and New Mexico. In order to show the relative distribution of the rainfall and the physiographic features that influence the choice of species for planting, the region has been divided into four belts, named, respectively, the Lowlands, Cross Timbers, Red Beds, and Plains. These belts are shown on the accompanying map. Their boundaries have been made to coincide with the even thousand-foot contours, since those intervals represent quite truthfully the varying character of the forest growth.

The Lowlands Belt is so named because a large part of its surface is occupied by broad, flat river bottoms; the Cross Timbers Belt is named from the Upper Cross Timbers of Texas, which extend into this belt from the south; the Red Beds Belt is named from the geological formation prevailing in western Oklahoma and the eastern part of the Texas "Pan Handle"; and the Plains Belt is named from the high plains which extend from western Texas northward along the eastern front of the Rocky Mountains.

FOREST SUPPORTING CAPACITY OF THE REGION.

For several years past the Forest Service has been cooperating with farmers in making forest plantations. It has made planting plans for seventy-six landholders in Oklahoma and adjacent regions, in accordance with its Circular No. 22, and the information here published has been collected by the agents of the Service chiefly in connection with the making and execution of these planting plans.

A planting plan, as prepared by the Forest Service, is a detailed statement of all the operations necessary to establish and maintain a forest plantation upon a specific tract of land. Before a planting plan of value can be made, the nature of the soil and subsoil of

the planting site, the climatic conditions of the region, and the qualities of the tree species that may be planted must be thoroughly considered. Further, a planting plan applicable to a farm on the prairies or plains requires that the whole system of farm management be considered. The forest plantations on any farm must be subsidiary to the business interests of the farmer. A plantation might be made that would not only be useless, but a positive damage to the farm.

The planting plans described herein were prepared with special reference to the wants of farmers and other tree planters, and to the local conditions in the belts to which each applies. The model planting plan (pp. 31–36) has been made to fit practically perfect conditions on a flat prairie. While it is quite probable that this plan unmodified could be applied on but a small proportion of the farms of the region, it illustrates principles that are fundamental to any useful planting plan. It is expected that farmers using the plan will modify it to fit their needs and opportunities.

THE ABILITY OF THE REGION TO SUPPORT FORESTS.

A large part of this region is practically without natural forests, and only a small part of it is capable of growing trees without cultivation. The Lowlands Belt is potentially a forest area, but westward of its borders climatic conditions become more and more inhospitable to tree growth. A large part of the region lies where prairies and plains merge. The rainfall decreases steadily from upward of 38 inches per year in the southeast to less than 12 inches in the northwest. This is due to a situation which gives the eastern portion the benefit of moisture-laden winds from the Gulf of Mexico, but leaves the western portion under the control of the dry winds that descend from the Rockies—for in this case the common law that increasing altitude is correlated with increasing humidity is contradicted. The figures on the map (Frontispiece) show how the average annual precipitation decreases steadily from the eastern to the western stations, and emphasize the necessity for considering the rainfall and other climatic factors of each locality when making a planting plan. As a rule the seasonal distribution and character of the precipitation must be studied also, since it is often true with trees as with field crops that a moderate rain during the growing season is of more value than a heavy rain after growth has ceased.

The great fertility of the soil, together with the rapidly increasing population, gives promise that this part of the country is destined to a large development. For these reasons every effort should be put forth to overcome the unfavorable conditions which hinder forest planting and thus retard the region's development. There is no doubt that by carefully selecting the species, choosing suitable situa-

tions, and properly managing the plantations, useful forest trees may be grown in every county of the region. In the three western belts, however, it will be necessary for landowners to give careful consideration to the choice of the ground for forest planting, since the amount of land suited to tree growth is relatively small.

THE CARE OF FOREST PLANTATIONS ON THE PRAIRIES AND PLAINS.

Successful forest planting on the plains, where the rainfall is light and irregular and the evaporation great, depends largely upon the proper tillage of the soil. The region possesses a deep, rich, easily worked soil, which the farmers are learning how to utilize to the best advantage. The early tree planters often set their trees carelessly, and left them to struggle with the native vegetation and dry weather. Planters are now beginning to realize that trees as well as agricultural crops respond to good cultivation.

The objects of cultivation are two: First, to prevent the growth of weeds and grass; second, to conserve the soil moisture. The natural supply of moisture on the plains is sufficient for the growth of many species of trees, provided it is fully utilized and not allowed to escape through evaporation or to be appropriated by weeds and grass.

TREATMENT OF THE SOIL.

Before the trees are set, the ground should be thoroughly worked and put in good condition. Virgin sod should be broken and the land farmed for two or three years. Deep plowing, followed immediately by the harrow, saves moisture and makes the soil easily penetrable by the roots. After the trees are set there should be frequent shallow cultivation. An ideal method is to cultivate as soon as practicable after every rain, in order to maintain a dust mulch over the surface. The nearer this ideal is approached, the better the results will be. The dust mulch is the best medium to conserve the moisture already in the ground, and to keep the soil in condition to absorb the next rain.

MULCHING.

A mulch of hay, straw, or well-rotted manure may be used where cultivation is not feasible, but it is not to be generally recommended. The mulch retards the growth of weeds, checks evaporation, and prevents baking of the soil, but if continued long it causes the roots to grow close to the surface, so that when the litter is removed they are likely to be damaged by the exposure. The mulch has another disadvantage in that it furnishes a congenial harbor for mice and all kinds of insects. A mulch of hay or straw is less objectionable

around trees set in the sod, where it is inconvenient or undesirable to cultivate. Along a hedge row, for instance, a mulch may be of great benefit.

SPACING THE TREES.

The advantage to be gained by continued cultivation of a forest plantation makes rather wide spacing advisable, even though certain species which have a spreading habit may require pruning, so that the trunks may grow clear and the cultivation not be impeded. Compensation for the wide spaces between the rows can be secured in large measure by setting the trees closer in the rows. The spacing of many plantations is 4 feet by 4 feet, but trees set in that way can be cultivated only two or three years. Spacing 2 feet by 8 feet gives the same number of trees to the acre, and makes it possible to continue the cultivation much longer. Species which need more room can be set 3 feet by 8 feet or 4 feet by 8 feet, and, as they grow, the space required can be obtained by removing the less promising individuals. The less cultivation that is to be given a plantation the closer the trees should be set; for, in the absence of artificial methods of conserving the soil moisture, the stand itself must be dense enough to shade the ground and furnish a litter which will maintain the proper moisture conditions. Without this the trees will neither grow rapidly nor preserve their vigor. On the semiarid plains, however, wide spacing and frequent cultivation will produce better trees than close spacing and little cultivation.

SITUATIONS WHERE CULTIVATION IS UNNECESSARY.

In river and creek valleys, where water is found at from 5 to 20 feet below the surface, cultivation is not ordinarily necessary after the trees are thoroughly established. The same is true in many places on the upland, where shallow depressions catch the run-off from considerable adjoining areas. In such situations the supply of water may be concentrated on any desired part of the depression by running furrows to it from the surrounding slopes. This method has been successfully used by some of the most progressive western farmers.

FALL CULTIVATION HARMFUL.

Cultivation should not be continued too late in the fall, or tender young shoots, which may not be able to withstand the winter, are likely to be produced after the normal growth has ceased. The wood should have time to harden before cold weather sets in. If the ground has been kept clean, weeds will give little trouble after the middle of August.

The planting of field crops between rows of young trees on the plains is unwise; the trees need all the available moisture. Corn is especially harmful, because the roots spread both down and out from 5 to 8 feet and take much more soil moisture than the young trees. If any crop is planted, it should be a short-lived one of the garden kind, whose roots do not spread far and are soon gone.

TOOLS—METHODS OF CULTIVATION.

The plow has no place among trees, other than to prepare the ground for planting. The plantation is often neglected until the weeds have formed a dense growth 3 or 4 feet high, and then the ground between the rows is plowed. The plow leaves the ground rough, a condition which greatly increases the loss of soil moisture through evaporation. Dead furrows are formed between the rows or the earth is thrown away from the bases of the trees and many roots are cut, which does great injury to the trees.

The best implements for the cultivation of the ground are the pulverizing harrow, the disk harrow, the dagger-tooth harrow, and the five-tooth cultivator. The pulverizing harrow is an excellent tool for shallow tillage, and, when used frequently enough, is all that is necessary. Where the weeds are large an ordinary cultivator may be put in or a shallow disking given, but to give the best surface conditions the disk should be set rather slanting or be followed by a harrow. A single section of a dagger-tooth harrow, drawn by one horse, may be used advantageously between the rows of trees. The five-tooth, one-horse cultivator requires the least space of any of the tools mentioned and can be used when the rows are close together or after the trees have grown so as to fill most of the space between the rows.

Care should always be taken that the stems of the trees are not injured in any way. There should be no projecting parts about the cultivator or the harness, but if such parts are unavoidable they should be wrapped with pieces of old sacks.

GRAZING—FIRE.

Grazing animals should be rigorously excluded from all tree plantations until growth is well advanced. Even if the trees are too large to be broken off by the stock, every branch within reach will be browsed, and the desirable forest conditions of shade, undergrowth, and litter will be destroyed. In a well-established grove stock may do little harm, but until the crowns of the trees are entirely

out of reach cattle should not be admitted. Even then injury may result from the trampling of the soil. A heavy soil becomes packed so that it is nearly impervious to water, while a sandy one is worn and blown away, leaving the roots exposed. The damage to large trees in situations where moisture is abundant is not usually great, and the protection furnished to stock in such a case may more than offset the slight injury to the trees.

Every tree plantation needs to be protected by some form of fire guard. Where conditions permit, a very satisfactory guard is made by plowing two or three furrows about the plantation close to the trees and then making a second series of furrows from 1 to 2 rods outside the first. These lines may be kept free from vegetation by replowing each year, or they may be used for crops that do not easily burn. The space between the two series of furrows should be kept free of all combustible material by burning it over at safe times.

SETTING OUT TREES.

THE PROPER SEASON.

The best time to transplant young trees is just before growth begins in the spring, while the vital functions are still dormant and the seedlings liable to receive the least injury. In general this is just after the frost is out of the ground. Fall planting in the prairie States is usually unsatisfactory. The dry, freezing weather of the winter frequently exhausts the moisture of firmly rooted young trees, and kills them. This is due to the fact that the frozen roots can not supply moisture to the stem as rapidly as it is given off from the twigs exposed to the cold, dry winds. A newly transplanted tree is placed at a much greater disadvantage during the winter season than a tree whose roots have a hold upon the soil. Spring planting is therefore advisable in almost every case. If the tree to be moved is so large that it is necessary to curtail the root system very severely, the work of digging should begin early in the fall, permitting a ball of frozen earth to adhere to the roots to protect them while the tree is being removed late in the winter. Forest plantations, however, should be made with quite small trees, and the methods of handling them may be very simple. As a rule, deciduous trees should not be over 2 feet high and evergreen trees not over 8 or 10 inches. Farmers more often make the mistake of planting trees that are too old than those that are too young. Any addition to the height of a deciduous tree after it has attained one full year's growth is a drawback for planting, because increased size diminishes the chances for successfully transplanting it and increases the labor of the operation.

By establishing a home nursery close to the planting site the disad-

vantages of shipment may be avoided, some expense saved, and the time for planting considerably extended. The last point is often of importance because it may be inconvenient to drop other work to give a shipment of trees the immediate attention that they require. Home-grown stock can be left in the nursery until a favorable opportunity for setting out the trees occurs.[a]

It is always well to choose a wet or cloudy day for transplanting, but if the work must be done in dry weather the nursery beds or trenches should be thoroughly soaked a few days before moving the trees.

When a tree is removed from the ground its roots should be immediately plunged into a mixture of earth and water about as thick as cream. This mixture is known as "puddle," and is one of the most important requisites to successful tree planting. The puddle may be prepared in a large tub and drawn on a sled along the row where the digging is in progress.

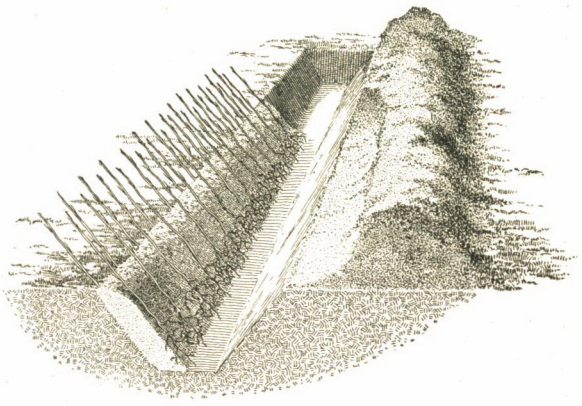

FIG. 1.—Heeling in young trees.

HEELING IN.

If seedlings are received from a distance, the boxes should be opened immediately, the trees unpacked, and their roots dipped into a puddle. After this the trees should be "heeled in" according to the following method until ready to be planted in the field. (See fig. 1.)

Dig a trench big enough to bury the roots and part of the stems. The trench should run east and west, with its south bank at a slope of about 30 degrees to the surface of the ground. A layer of trees should be placed in the trench on its sloping side, their tops toward the south. A second trench should then be dug, covering the roots and stems with the fresh earth from this trench, and so on until all the trees have been heeled in.

In case of conifers care should be taken not to bury the foliage and to shade the young trees with brush or with a shelter constructed of laths.

[a] Bulletin No. 29, The Forest Nursery, gives much valuable information on this subject, and may be obtained by addressing The Forester, U. S. Department of Agriculture.

PLANTING DECIDUOUS TREES.

Deciduous trees may be planted in lister furrows, as later described. In this region it is always advisable, previous to planting, carefully to till the whole area to be planted, except where the soil is so sandy that it will blow about if disturbed. When the young tree is finally set the stem should be buried 2 or 3 inches deeper than it was in the nursery, and in this region it is always desirable to leave a slight depression around the base of the tree to collect moisture.

In many cases the planter will find it entirely practicable to plant the seed of oaks, hickories, and walnuts in the permanent site rather than to buy the trees or grow them in a nursery. The nuts may be put into the ground in the fall or kept over and planted in the spring, as is most convenient. They should be spaced the same as trees from the nursery and covered with from 1 to 3 inches of earth. Plantations thus made should be well cultivated until the young trees become established.

The ripe seeds of many trees are often infested with the larvæ of insects, which, if allowed to remain alive for a few weeks, will destroy the germs. Acorns, chestnuts, and pecan nuts are especially subject to this trouble, though hickory nuts suffer less. The seeds of locust, mesquite, coffeetree, various pines, and other conifers are also apt to be attacked. In order to save infested seed, it should be treated with carbon bisulphid gas as soon as possible after it is ripe. Instructions for doing this are given in Farmers' Bulletin No. 145, prepared by the Bureau of Entomology, which may be had upon request directed to the Department of Agriculture. Various directions for destroying nut weevils are also given in the Yearbook of the Department of Agriculture for 1904.

PLANTING BY HORSEPOWER.

A very rapid and inexpensive method of planting by the aid of horsepower has been successfully employed on well-tilled land in the prairie States. This method is suitable for broadleaf species only, and the best results and greatest economy require the services of 10 men, 4 boys, and 5 horses. The implements necessary are 10 spades, 2 buckboards, 4 empty barrels, 1 lister, and 1 wheel cultivator. One or two additional spades or shovels should be placed where the trees are heeled in, as a reserve in case any of the implements are broken.

One man with a lister and three horses furrows out the rows ahead of the planters. In two hours he can furrow out enough ground to keep the whole force at work five hours. The trees are planted in the bottoms of the furrows in openings made with a spade at right angles to the furrows. Two men work together, each on a row, to whom a boy hands the trees from barrels containing water or "pud-

dle," which are carried along on a buckboard between the planters. While one load of trees is being distributed to the planters another load is being put into the barrels on the other buckboard. One man will be constantly required to replenish the barrels on the buckboards, to drive the loads of trees out into the field, and to bring back the vehicles with their empty barrels.

Each planter with his spade makes an incision in the bottom of the furrow as deep as possible, and then pries back and forth on the spade handle until the cleft is 3 or 4 inches wide. The boy at the barrel hands him a tree and the planter inserts it into the opening, taking care to spread its roots in fan shape; then, with two strokes of the spade, earth is scraped down from each side of the furrow against the tree. As the planter advances to make the next incision, he tramps the earth around the tree he has just planted. The most necessary precautions are to be sure that the roots are covered and that the trees will stand erect until the furrow is filled by the cultivator. The man with the lister, after an hour's work, unhitches from this implement and hitches up to the wheel cultivator. With this he follows the planters, filling in the earth around the trees, and thus completing the planting operation. One man with 3 horses can open and fill up the furrows for 8 men planting with spades, while 4 boys can hand out the trees from the barrels if the supply of trees is kept replenished by another man. With this equipment, 8,000 trees can be planted in ten hours, or 4 acres can be covered in a day if 2,000 trees are planted per acre. The following is a liberal estimate of the cost of planting by this method:

10 men, at $1.50 each per day	$15.00
5 horses, at 50 cents each per day	2.50
4 boys, at $1 each per day	4.00
Wear and tear on machinery	2.50
Total	24.00
Cost per acre	6.00

A less efficient crew for planting may be composed of 3 men, 1 boy, and 4 horses. Two men do the planting, one man with a lister and cultivator furrows out and fills up the trenches, and the boy hands out the trees. The teamster can replenish the trees in the barrel from time to time as his work with the team is slack. By this method the cost of planting 2,000 trees to the acre will be about $9.

TREATMENT OF EVERGREEN TREES.

Evergreen trees should be planted in the same way as deciduous trees, but must be handled with much more care. The roots should never be allowed to dry, and every precaution should be taken to

keep them from the air. In the nursery the trees should be shaded from the direct rays of the sun by brush, cloth, or lattice screens, and they should not be taken up when the air is dry. If they are not transplanted directly from the nursery they should be left heeled in until the weather is propitious. A cool, cloudy, damp day should be selected in which to plant. When heeling in, the foliage should never be covered with soil, and when planting out, the stems should be set but a little deeper than they were in the nursery.

Unless the planter proposes to use a large quantity of evergreen trees it will be best to buy stock one or two years old from a nursery, and cultivate it in beds until it is large enough to set out. For ordinary plantations small trees are preferable. Evergreens are particularly difficult to transplant after they are more than a foot high. If they live, their growth is usually so checked by the disturbance of their roots that after a few years they are outstripped by similar trees considerably younger. In short, small trees cost less than large ones, they are more easily transplanted, they are more apt to live, and they usually reach maturity, or a full development, quite as soon as those that are larger at the time of planting.

Chinese arborvitæ and a few species of pine and cedar are the only evergreens suitable for planting in the greater part of this region.

PLANTING PLAN SUITED TO THE LOWLANDS BELT.

The following planting plan, although made for a farm situated from 30 to 40 miles east of the ninety-sixth meridian and outside of the territory covered by this study, is suitable for most of the Lowlands Belt. The farm consists of the south half of section 27 and the north half of section 34. Fig. 2 shows that portion covered by the planting plan. This part of the Indian Territory is undulating, and is underlaid with soft carboniferous sandstones and shales. A few miles east of this farm is Pryor Creek, which has a broad, fertile, alluvial valley, and but a few miles farther east is the valley of the Grand or Neosho River. Beyond the Grand River the country rises rapidly into the foothills of the Ozarks, which are covered by unbroken forest.

This farm is situated on a prairie. Some fine groves of post oak, hickory, elm, and other species grow on the uplands in this vicinity, and persimmon is abundant on the more rocky ground. The creek and river bottoms, where not in cultivation, produce fine specimens of black walnut and pecan. The altitude is between 700 and 800 feet above sea level. The average annual rainfall exceeds 35 inches, though it is sometimes so distributed that droughts occur. These and frequent high winds are the chief unfavorable climatic influences.

FIG. 1.—A "LISTER" DOUBLE MOLDBOARD PLOW, MAKING SHALLOW FURROWS FOR PLANTING LOCUST SEED.

[When used for opening furrows for planting trees three large horses or mules are required.]

FIG. 2.—PLANTING FOREST TREES IN LISTER FURROWS ON THE SEMIARID PLAINS.

[Squad not organized for quick work.]

FIG. 1.—A PORTABLE SAWMILL CONVERTING INTO LUMBER COTTONWOOD LOGS FROM PLANTED TREES 15 YEARS OLD, KINGMAN COUNTY, KANS.

FIG. 2.—LOCUST ON AN ABANDONED "TREE CLAIM" IN SOUTHWESTERN KANSAS.

[The trees have been preserved from fire by cattle tramping the grasses out near them.]

As shown in fig. 2, two sites were chosen for forest plantations: An L-shaped tract 80 feet wide and about 100 rods long, south and west of the orchard, to be planted as a windbreak; and second, a broad strip along the small stream in the lowest part of the south half of the farm. The plan provides that on the narrow L-shaped strip, the eastern 33 rods are to be planted to pure hardy catalpa, a section 40 rods long west of the catalpa to black walnut and

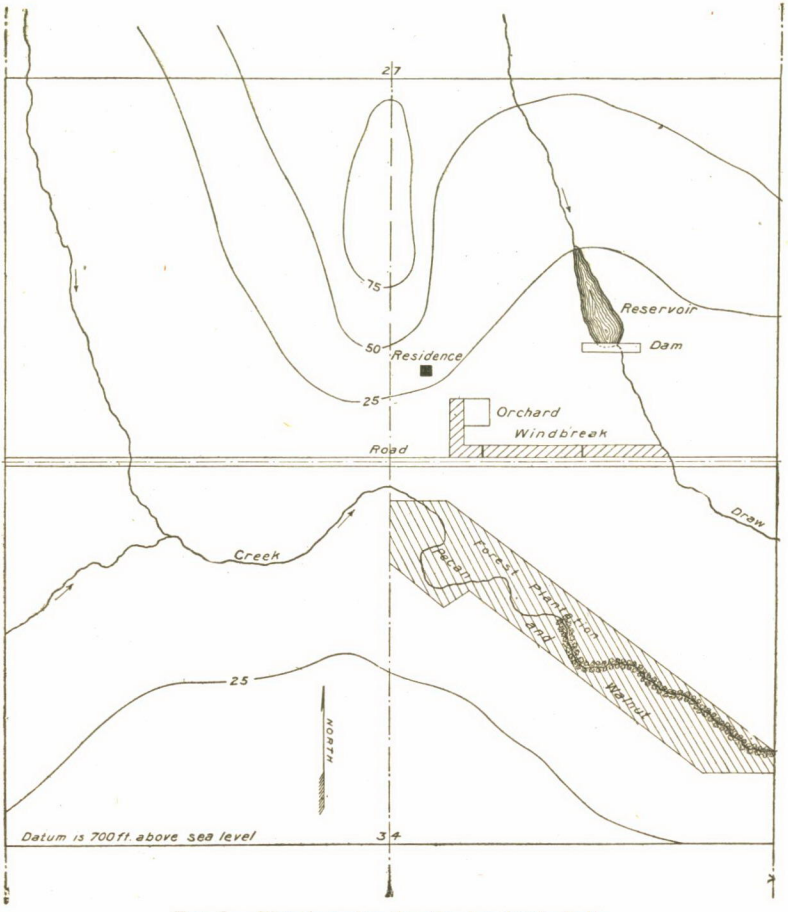

FIG. 2.—Planting plan for the Lowlands Belt.

red oak, and the remainder to coffeetree and bitternut hickory in equal proportions. The strip along the small creek is to be planted to black walnut and pecan.

These plantations are intended to furnish posts and high-grade lumber, as well as to afford protection to the farm. All the trees are rapid growers in this section, and the quality of their wood is well known. It should be noted, however, that young, quickly grown trees

usually have more sapwood than those of the same kind that grow slowly, and hence have wood that is less durable and sometimes less valuable in other ways than old trees. Young black walnut in particular generally has a large portion of light-colored sapwood that is relatively of little value. Catalpa, however, produces little sapwood under any circumstances, and the rapidly grown wood is more valuable than that grown slowly, because straighter. The sapwood of hickory is tougher and better than the heart.

The catalpa trees are to be set 3 feet apart in rows 8 feet apart, the walnut and red oak approximately 4 feet by 8 feet, and the mixtures of hickory and coffeetree the same. The walnut and pecan are to be set 6 feet by 8 feet, in order that they may produce nuts as well as timber. No attempt was made to set the trees in check rows on any of these plantations. The wide spacing in one direction will permit long-continued tillage, which is very desirable, particularly with the nut trees.

If the plantations made under this planting plan are carefully attended to, the growth of the trees, particularly of the catalpa, will be so rapid that some returns may be expected within ten years. At that age about half the catalpa trees in the pure plantation should be cut out for fence posts. After about fifteen years more the remainder should be suitable for telegraph poles. If the latter are desired, the side branches should be pruned from the trees as soon as they die.

The following diagrams illustrate practicable methods of planting the various species proposed for this plan:

DIAGRAM 1.—*Mixture for bottomlands and rich slopes in the Lowlands Belt.*

(Spacing, 8′ by 4′.)

X	W	X	W
W	X	W	X
X	W	X	W
W	X	W	X

W=black walnut or hickory. X=coffeetree or red oak. Vertical distance X to X equals horizontal distance X to W.

REQUIRED NUMBER OF TREES PER ACRE.

Black walnut or hickory	680
Coffeetree or red oak	680
Total	1,360

DIAGRAM 2.—*Mixture for rich bottomlands in the Lowlands Belt.*

(Spacing, 8′ by 6′.)

P	W	P	W
W	P	W	P
P	W	P	W
W	P	W	P

P=pecan. W=black walnut.

REQUIRED NUMBER OF TREES PER ACRE.

Pecan	454
Black walnut	454
Total	908

PLANTING PLAN FOR A DEMONSTRATION AREA IN THE LOWLANDS BELT.

This plan was prepared for the campus of Henry Kendall College, Muskogee, Ind. T. The purpose of the planting was to furnish shade and protection from hot winds, to provide instruction for the students of the college, and to adorn the grounds. The general plan of the college grounds, comprising a tract 1,060 feet square in the suburbs of the city of Muskogee, had been made prior to the preparation of this planting plan, and with it the Forest Service had nothing to do. Any distinctly ornamental planting should be planned by a landscape gardener, since work of this kind does not come within the province of forestry. But because this plan gives a key to what kinds of trees may be successfully grown in this region it has been deemed advisable to publish it.

That part of the Indian Territory about Muskogee is underlaid with alternating sandstones, shales, and coal measures. The rocks are soft, and, disintegrating very rapidly under the action of the weather, cause all inequalities of surface to become rounded off into wave-like swells. As a result of these conditions the surface is furnished with a deep, porous, chocolate-colored, loamy soil of great fertility. Here and there on the swells of the prairie the remnants of the disintegrating sandstones crop out and render a small part of the land unfit for cultivation until after it has been cleared of stones. Such an outcrop occurs on the campus of Henry Kendall College. It is not a hindrance to forest growth, but favorable to it.

The greatest climatic disadvantages are excessive heat and occasional droughts. The average annual rainfall is more than 35 inches and would be abundant for the growth of both forest trees and agricultural crops if it were somewhat better distributed. The native hardy species, like the oaks, have little difficulty in withstanding these conditions; hence this part of the Indian Territory, though a prairie country, is potentially forest land.

The chief planting site at Henry Kendall College is a semicircle located directly in front of the main college building, with a radius of 320 feet. (See fig. 3.) Hedges and windbreaks are provided to protect the athletic park, gardens, and orchards. Single lines of trees along the drives and near the outer boundaries of the tract are intended to add to the beauty and comfort of the situation.

A very important part of the plantation is the nursery, occupying a strip 75 feet wide at the east edge of the semicircle. This is to be used for demonstrations to the students of forestry and to produce a supply of young trees for planting on the campus. The portion of the semicircle west of the nursery is to be devoted to the growth of as many hardy species as is practicable. In general, a single species will be set in each row, and the trees of the whole plantation will be set 4 feet apart, in rows 8 feet apart. The following species have been recommended:

Green ash.
White ash.
Red cedar.
Wild cherry.
Wild china.
Chinese arborvitæ.
Coffeetree.
Slippery elm.
White elm.
Winged elm.
Gingko.
Hackberry.
Bitternut hickory.
Shagbark hickory.
Black walnut.
Honey locust (thornless variety).
Norway maple.
Sugar maple.
Red mulberry.
Bur oak.
Pin oak.
Post oak.
Texan oak.
Russian wild olive.
Pecan.
Persimmon.
Austrian pine.
Scotch pine.
Sassafras.
Shittimwood.

The hedge on the south and west sides of the athletic park will consist of Osage orange set 1 foot apart in a single line. The windbreaks south of the garden, west of the boys' dormitory, and south of the orchard in the northwest corner of the campus, are to be of Russian mulberry planted 3 feet apart in single rows. The windbreaks east of the garden and barnyard will be made of Mariana plum and wild plum, respectively, planted 4 feet apart in single rows. In either of these windbreaks, the common sour or Morello cherry may be substituted, if desired. The purpose in planting the

plums and cherry is to secure thickets of sprouts that will screen the undesirable view of the back lots, and also act as windbreaks. The species to be used for this purpose are white elm, hackberry, sugar maple, and Norway maple.

The rows of shade trees along the drives and fences, where the planting has failed, should be replaced at once with white elm, hackberry, sugar maple, and Norway maple. These species are very hardy and well adapted to such exposed situations.

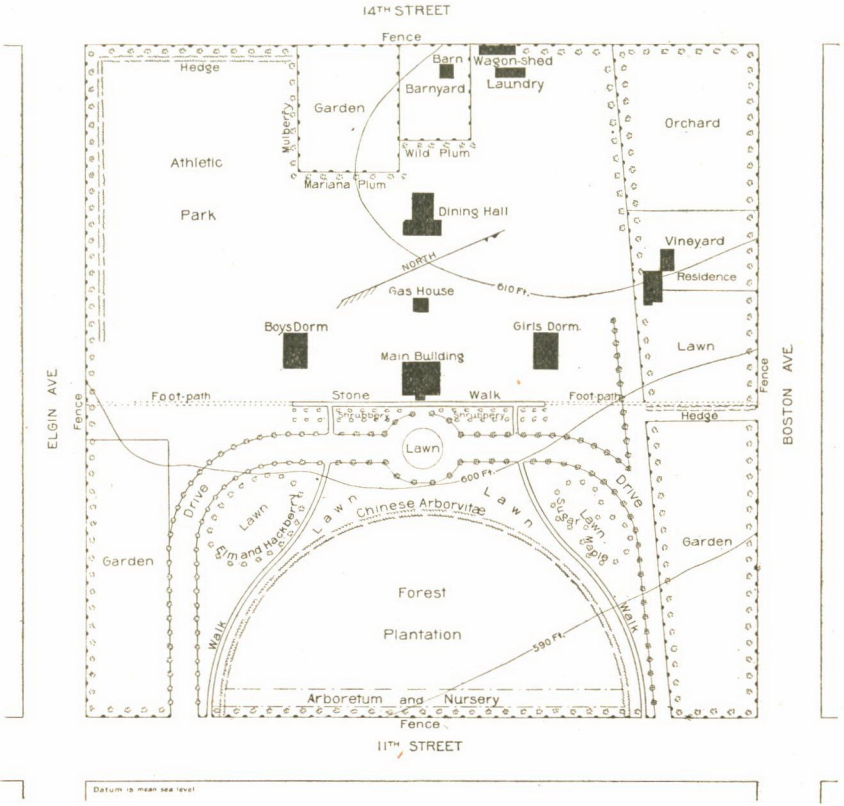

FIG. 3.—Planting plan for a demonstration area in the Lowlands Belt.

The arboretum that is also planned may contain the remnants of the nursery stock and any introduced trees or shrubs that are deemed worthy of trial. Many shrubs serve a useful purpose in forestry by shading the ground and keeping out grasses where the canopy of the main forest stand is open. The native shrubs invariably act as the advance guard of the forest in its encroachment upon the prairie. The following trees and shrubs were recommended for planting in

the arboretum, though some of them will doubtless prove to be suitable for moist soils only:

Althea.
Azaleas.
Blue ash.
Bellwood.
River birch.
Cut-leaf white birch.
Choke cherry.
Flowering currants.
Bald cypress.
Deodar.
Flowering dogwood.
Redtwig dogwood.
Forsythea.
Red gum.
English hawthorn.
Black haw.
Red haw.
Hophornbeam.
Hop tree.
Irish juniper.
Lilacs.
Magnolias.
Cut-leaf silver maple.
Dwarf maples.
Mock orange.
Shingle oak.
Russian wild olive.
Siberian pea-tree.
California privet.
Japanese quince.
Giant rhododendron.
Native roses.
Siberian rose.
Spiræas.
Tamarix.
Wahoo.
Weigelias.
Yellowwood.

In recommending this plan to the college authorities, the Forest Service advised them as follows:

All the planting sites should be broken out and given good tillage for two or three years prior to the planting of the trees, in order that the prairie grasses may be subdued. After planting, the ground between the rows of trees should be kept in cultivation as long as possible. During the growing season cultivation should be as frequent as once a month. The surface should not be ridged by the cultivator, but should be kept flat. Where the rows are 8 feet apart garden vegetables may be grown between the trees for the first two or three years, since the cultivation of the crops will also serve for the trees.

The species that should be grown from seed in the nursery and transplanted to a forest site when one or two years old are the following:

Green ash.
White ash.
Wild China.
Black cherry.
Coffeetree.
Slippery elm.
White elm.
Winged elm.
Gingko.
Hackberry.
Honey locust.
Norway maple.
Sugar maple.
Mulberry.
Russian wild olive.
Osage orange.
Pin oak.
Red oak.

Species that are not easily transplanted because of the development of a long tap root and whose seed should consequently be planted in the permanent position, are the following:

Bitternut hickory.	Post oak.
Shellbark hickory.	Pecan.
Bur oak.	Walnut.

Persimmon, sassafras, shittimwood, and wild plum may be most easily secured from the neighboring woods. They should be taken up when quite small, and set in their permanent positions. The evergreen trees should be purchased from a nursery as small seedlings and planted in nursery rows, where they should be cultivated for two or three years prior to transplanting to the permanent site.

PLANTING PLAN SUITED TO THE CROSS TIMBERS BELT.[a]

The following planting plan was made for a farm located 3 miles west of the town of Kingfisher, Okla., and may serve as a model for similar locations in the Cross Timbers Belt.

The land lies on the north side of Kingfisher Creek, a stream which flows east and thence north into the Cimarron River. The topography and soil in this vicinity are peculiar, but that fact does not affect the value of the planting plan for other locations. The slope is southward, and about one-half mile from the creek the land drops rather sharply to the creek bottomland. Several ravines lead from the upland into the valley. The soil of the upland was formerly clay, but a stratum of sand now overlies it. The sand probably was deposited by wind, though it is by no means a recent formation. Below the clay there is generally a red shale or sandstone, which is impervious to water. In consequence of this formation there is a general seepage of water along the slope where the clay crops out. The ravines are therefore full of springs, a number of which have been developed, and numerous pools are fed by them. Unless the slope is ditched or the water is led into pools, the land in the valley at the foot of the uplands is wet and frequently difficult to cultivate in spring. The farm for which this planting plan was made includes this slope, extending east and west across it. About one-fourth of the farm lies in the valley and three-fourths on the slope and upland.

Much tree planting has been done in the neighborhood, most of it upon the upland, and is successful. The owner of this farm has silver maple, box elder, and Russian mulberry growing nicely; and on other farms catalpa and black locust are doing well, the latter growing best of all. Cottonwood does finely in moist places. Along Kingfisher Creek, one-half mile south of the farm, white elm, hack-

[a] This planting plan was proposed by Mr. William L. Hall, Assistant Forester in the Forest Service.

berry, and black walnut occur naturally as large trees. Pecan also grows well on the bottom lands.

The planting plan provides for a plantation of 10 acres, 40 rods square, situated southwest of the buildings and orchards. The site lies wholly in the valley, and has a tendency to wetness at certain times of the year. There is a gradual slope to the south, but aside from this the surface is even. The soil is fertile, except on a spot of about one-eighth acre on the south side, containing unproductive yellow alkali soil, which should not be planted. This site has been under cultivation for four or five years, and is in good condition, the wild grass roots being well decayed. The main purpose in establishing the plantation is to provide useful material for fencing and buildings, and also to have posts and poles to sell for profit. The owner also desires to protect his buildings and orchards from the hot southwest winds. He is especially favorable to the hardy catalpa, and desires to make it the leading tree in the plantation. This species, therefore, as well as black locust, Russian mulberry, and black walnut, is provided for in the planting plan, since these trees are the best that can be used in this location. It was recommended that, so far as possible, the stock should be grown from seed. Catalpa seed can be obtained from a dealer, black walnut nuts are at hand, and locust and mulberry seed can be found in the neighborhood.

The main plantation will be composed of hardy catalpa, black walnut, and black locust, the catalpa planted in every second row running north and south, and the walnut and locust alternating in the intervening rows. The trees are placed 5 feet apart north and south, and 4 feet apart east and west. On the south and west sides of the plantation two rows of Russian mulberry are to be planted, with the same alignment as the trees in the main plantation.

The following diagram illustrates the method of planting advised for this case, without the two rows of Russian mulberry on the south and west borders:

DIAGRAM 3.—*Mixtures for Cross Timbers Belt.*

(Spacing 4′ by 5′.)

C W C W C W

C L C L C L

C W C W C W

C L C L C L

L=Black locust. C=Hardy catalpa. W=Black walnut.

REQUIRED NUMBER OF TREES PER ACRE.

Hardy catalpa	1,089
Black locust	544
Black walnut	544
Total	2,177

PLAN FOR A COMMERCIAL PLANTATION IN THE RED BEDS BELT.

The following planting plan was prepared for a quarter section of land located about 5 miles northwest of the town of Stafford, Kans. The country is an open, treeless prairie, very slightly undulating. There are no creeks or draws affording surface drainage, but in the northwest corner are portions of a very low range of sand dunes, which make the surface less uniformly flat than the rest of the tract. Parts of these dunes are rather too sandy to grow agricultural crops successfully. The soil in general is a fertile sandy loam about 2 feet in depth, grading into a subsoil of sand which extends to an unknown depth. The water table is from 12 to 20 feet below the surface of the ground. The land has been in cultivation several years, and is in excellent tilth. The portion of the farm lying south of the Santa Fe Railroad track, containing about 110 acres, is well adapted to forest trees; the remainder of the quarter section will probably yield higher returns if devoted to fruit culture, and the plan provides for orchards in this portion, and also along both sides of the railroad, for a reason which will presently appear.

There are no trees growing naturally upon the tract or near it, but cottonwood and black walnut have done well when planted in similar situations. On a neighboring farm cottonwood trees have grown large enough for saw logs in twelve years. The following species are suitable for planting in this locality: Cottonwood, black walnut, hardy catalpa (only on the richest land), white elm, green ash, hackberry, Osage orange, Russian mulberry, honey locust, red cedar, and Chinese arborvitæ. Fig. 4 reproduces the sketch plan made for this tract.

The site upon which the hardy catalpa plantation was made consists of about 30 acres lying south of the Santa Fe Railroad track. The land was prepared by listing, and the trees were planted in the listed furrows so that they stand about 4 feet apart each way.

The following diagram illustrates the method that was followed in distributing these trees:

DIAGRAM 4.—*Pure plantation for Red Beds Belt.*

(Spacing 4′ by 4 .)

C C C C

C C C C

C C C C

C C C C

C=Hardy catalpa ; 2,720 trees per acre.

The trees were planted very expeditiously, most of the work being done by horsepower, as described on page 14. The tillage the first

two seasons following planting was about the same as that given a corn crop. At the end of the second or third year after the plantation has been made it will probably pay the owners to go through the plantation and select the most promising trees, about 500 to the acre, to constitute the final stand. These should be pruned and made to grow as straight and tall as possible. The rest of the trees should be left with their branches upon them. The sixth or seventh year after planting, about one-third of the whole number of trees should be cut out. These may then be used for fence posts, fuel, stakes, or

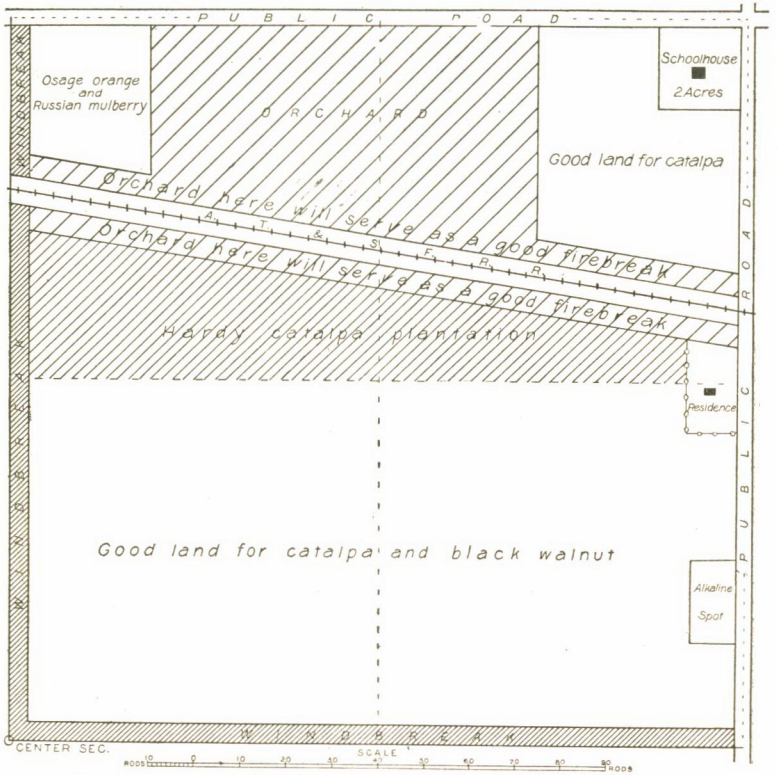

FIG. 4.—Plan for a commercial plantation in the Red Beds Belt.

other economic purposes. At the end of about ten years another thinning should be made, and a third in the fifteenth year.

As the plantation will probably be extended beyond the area planted the first year, the owners were advised that mixed plantations are usually more successful than pure. On the richest land of this quarter section, in its southern half, the catalpa and black walnut might therefore be mixed with advantage. If it is desirable to plant a mixture of this kind, it is suggested that walnuts be collected in the fall when ripe and planted by hand 2 feet apart in alternate lister furrows. The space between these furrows should be planted in corn

the following two seasons, and the corn and young walnut trees should be given like cultivation and attention. In the fall of the second season of the growth of these young trees the owners may go through and thin out the seedlings to stand about 4 feet apart in the rows. The third season small hardy catalpa seedlings may be planted in place of the corn in the intervening spaces between the rows of walnut trees.

The following diagram shows how these trees will stand after the walnuts have been thinned and the catalpas planted in:

DIAGRAM 5.—*Mixture for good soil in Red Beds Belt.*

(Spacing 4′ by 4′.)

C C C C

W W W W

C C C C

W W W W

C=Hardy catalpa. W=Black walnut.

REQUIRED NUMBER OF TREES PER ACRE.

Hardy catalpa	1,360
Black walnut	1,360
Total	2,720

In a plantation of this kind, honey locust might profitably displace one-half of the catalpa by being planted in alternation with it.

On the very sandy portions of the quarter section north of the railroad, Osage orange and Russian mulberry may be planted in equal proportions. These trees should stand 4 feet apart each way, and should be planted and cultivated in a manner similar to the catalpa. Seedlings 1 year old should be used, and the trees should be planted in alternate rows according to the following diagram:

DIAGRAM 6.—*Mixture for sandy land in the Red Beds Belt.*

(Spacing 4′ by 4′.)

O O O O

M M M M

O O O O

M M M M

O=Osage orange. M=Russian mulberry.

NUMBER OF TREES REQUIRED PER ACRE.

Osage orange	1,360
Russian mulberry	1,360
Total	2,720

The owners were advised to plant strips of pure cottonwood 4 rods wide on the south and west sides of the quarter section, to serve as windbreaks, these trees to stand 8 feet apart each way. Immediately north of the south belt of cottonwood, and east of the west belt, should be planted two rows of Russian mulberry or Osage orange, 4 feet apart each way, leaving a space of about 12 feet between the cottonwood and mulberry trees.

The railroad crossing the tract will expose the plantation to some risk of injury by fire, but if orchards are set out along the south side of the right of way as well as to the north of it, and are properly maintained, the forest plantation will be efficiently protected.

ANOTHER PLANTING PLAN SUITED TO THE RED BEDS BELT.

This plan, made for a farm near Berlin, Roger Mills County, Okla., is applicable to a large part of the uplands of western Oklahoma, particularly to the region underlaid with the Red Beds deposits.

The rock underlying this farm belongs to the Red Beds formation, and is a very soft, fine-grained sandstone, which weathers rapidly. A large part of Roger Mills County is covered with sand dunes derived from this rock, which readily absorb all the rainfall and allow the water to percolate down to an impermeable substratum, where it forms an underflow. The depth of this underflow, at the farm with which this plan deals, is from 15 to 25 feet. Springs occur along the arroyos, and water may be found 2 or 3 feet below the surface in many of the draws. The farm lies on a table-land sloping south, which skirts the south side of one of the above-mentioned ranges of sand hills at a distance of 3 or 4 miles from the farm. The altitude is about 2,000 feet above sea level and about 100 feet above the North Fork of Red River.

The soil on this farm is a fertile, red, sandy loam, composed of very fine particles, and at least 2 feet deep. It contains considerable quantities of alkali, but being also highly charged with gypsum, is capable of bearing good crops. It is not abundantly supplied with humus. The subsoil consists of the same materials, but is more firmly compacted, and often contains undecomposed fragments of the underlying Red Beds rock. Both soil and subsoil are receptive and retentive of moisture.

The climate of this part of Oklahoma is of the continental type common to the Great Plains. Seasons of bountiful rainfall are frequently followed by others of scanty precipitation. The intense heat of the summer, combined with almost constant winds, causes the dissipation and loss of a large part of the precipitation by evaporation.

No trees grow naturally on the farm, and there are no indications that any have ever grown upon it in the past, but the shin oak (Rocky

Mountain oak, *Quercus undulata*) forms thickets over great areas of the sand hills of this region, and along Starvation Creek, 3 or 4 miles from the farm, there is a natural forest growth consisting of cottonwood, coffeetree, hackberry, Mexican walnut, shittimwood, wild china, and red mulberry.

The problem of the tree planter in this section is to grow windbreaks that will themselves survive droughts and prevent the thirsty summer winds from absorbing the moisture needed by the crops. In this part of the Great Plains every farm of 160 acres should have at

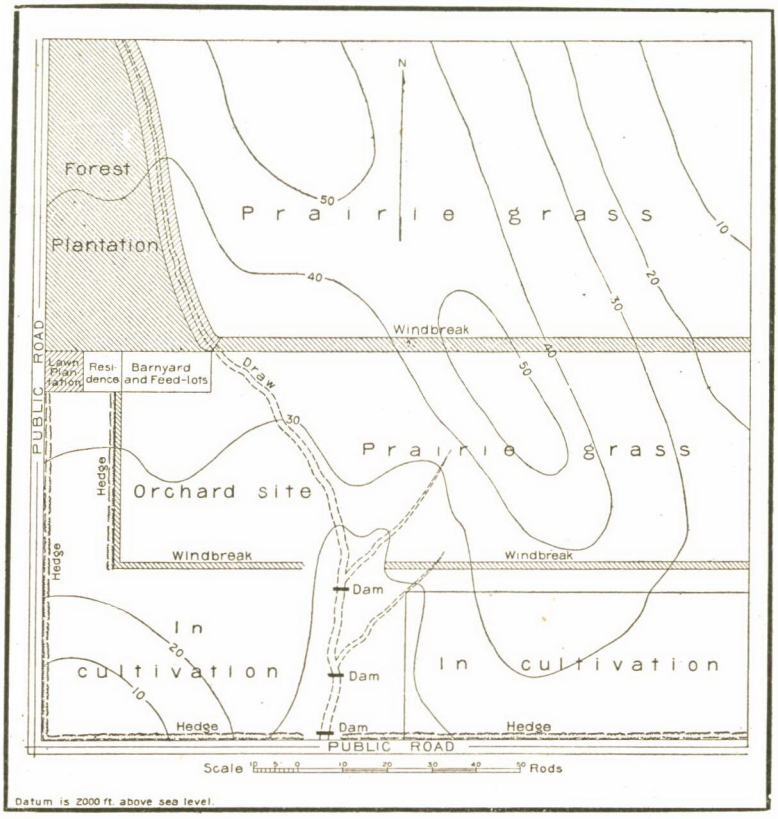

FIG. 5.—Another plan for the Red Beds Belt.

least 30 acres devoted to the farmstead, forest, and fruit trees; in this case the planting provided for aggregates 35 acres, including orchard and lawn. (See fig. 5.) These plantations are intended to shelter the orchard and building site, and to produce fence posts and fuel needed on the farm.

The best situation for trees is in the draw which crosses the farm from north to south. About 100 feet west of the northern end of the draw the poorest land on the farm is encountered. Here fragments of Red Beds rocks are found a foot below the surface.

Preparatory to planting, dams were constructed at intervals across the main draw, so as to store up the occasional excess of rainfall that would otherwise run off. The water thus stored serves to irrigate the garden and affords drink for the stock in times of drought.

The plantations that were proposed and made are the following:

(1) Two rows of cottonwood set 8 feet apart in the upper end of the draw, one row on either side of the trough.

Next each row of cottonwoods, and 8 feet distant from it, two rows of hardy catalpa 8 feet apart.

Outside the catalpa, two rows, also 8 feet apart, composed of black walnut and pecan set alternately in the rows.

The trees were set 4 feet apart in all these rows.

The plantation thus consists of 2 rows of cottonwood, 4 rows of catalpa, and 4 rows of walnut and pecan in mixture, and is in the form of a strip 72 feet wide following the course of the draw for somewhat less than half of its length.

(2) On the poor land in the northwest corner and immediately adjoining the plantation in the draw a strip of black locust 100 feet wide was planted 4 feet apart in rows 8 feet apart.

The rest of the corner, west of the locust and north of the farmstead, was planted with a mixture of Russian mulberry, honey locust, and coffeetree, according to diagram 7. This plantation, with those adjoining, made a solid block of forest north of the house and barn.

DIAGRAM 7.—*Mixture for poor soil in the Red Beds Belt.*[a]

(Spacing 8′ by 4′.)

M	L	M	L
C	M	C	M
M	L	M	L
C	M	C	M

M=Russian mulberry. L=Honey locust. C=Coffeetree.

REQUIRED NUMBER OF TREES PER ACRE.

Russian mulberry	680
Honey locust	340
Coffeetree	340
Total	1,360

(3) Beginning at the northeast corner of the barnyard and connecting with the plantation in the draw, a windbreak was planted straight to the eastern line of the farm. This windbreak is 3 rods

[a] The planter may substitute white elm for the honey locust and coffeetree if he chooses.

wide and is composed of black locust and white elm in alternating rows 8 feet apart. The trees are 4 feet apart in the rows.

(4) South and west of the orchard site a windbreak was planted composed of two rows of Russian mulberry on the side next the orchard and two rows of white elm on the outer side. These rows are 8 feet apart and the trees 3 feet apart in the rows.

(5) Beginning somewhat east of the draw, the windbreak south of the orchard was extended to the eastern boundary by planting black locust and white elm as in No. 3.

(6) West of the residence site a block 150 feet square was planted according to diagram 8, to serve as a shelter for the house.

DIAGRAM 8.—*Mixture for a windbreak or grove in the Red Beds Belt.*

(Spacing 8′ by 8′.)

A C A C

C A C A

A C A C

C A C A

A=Chinese arborvitæ (*Biota orientalis*). C=Red cedar.

REQUIRED NUMBER OF TREES PER ACRE.

Chinese arborvitæ	340
Red cedar	340
Total	680

(7) Cottonwoods were planted at intervals of about 8 feet around each pond formed by the dams in the draw.

(8) Along the south side, next the road, along the southern half of the western side, and outside the windbreak west of the orchard, hedges of Osage orange were planted, each consisting of a single row of plants set 1 foot apart.

The interval between most of the rows in these plantations is made 8 feet to permit of repeated tillage. Where rainfall is deficient the soil moisture can be conserved in that way. When the trees in these plantations are mature they will thoroughly protect the whole farm from the hot southwest winds.

In this plan a rather unusual number of tree species are provided for. All are suitable for the situation, however, and have valuable qualities. Hackberry, wild china, and western yellow pine probably will succeed also in many parts of this belt.

MODEL PLANTING PLAN FOR PRAIRIE FARMS IN OKLAHOMA.

The following planting plan is adapted either to the Cross Timbers or the Red Beds Belt. It has been prepared to illustrate the proper

arrangement of plantations so as to interfere as little as possible with the farming operations, to secure the greatest protection against wind, and to provide an abundant timber supply for a farm of 160 acres. As seen in fig. 6, the plan covers a whole section. By adopting it in its entirety four owners of adjacent quarter sections could cooperate to their mutual advantage. If the whole section is to be laid out by four different owners, the plan should be followed as it is,

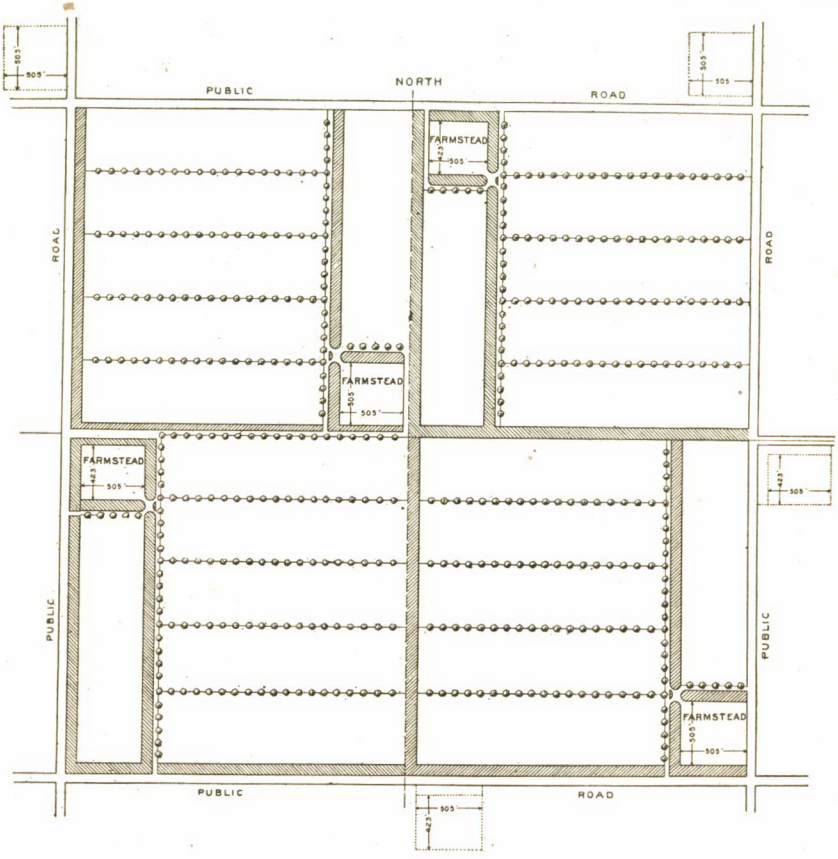

FIG. 6.—Model planting plan for a prairie farm.

but if only one quarter section is to be planted, the owner may choose from the four designs the one best suited to his desires.

Each quarter section is laid out with particular reference to the southwesterly winds—those that do the greatest damage to crops and orchards in this section. The northwest and southeast quarters are planned identically alike, except that the tree belt along the south side of the northwest quarter is reduced 2 rods in width to make room for a private road. East winds have not been specially considered with relation to the fields, since they are of such rare occurrence that

FIG. 1.—LOCUST AND HARDY CATALPA IN MIXTURE, EASTERN KANSAS.

[Planted in accordance with Planting Plan No. 57.]

FIG. 2.—GREEN ASH 4 YEARS OLD, STAKED PLAINS OF TEXAS.

[Planted in accordance with Planting Plan No. 37.]

FIG. 1.—LOCUST 5 YEARS OLD IN FOREGROUND; WHITE ELM IN BACKGROUND.

FIG. 2.—LOCUST 5 YEARS OLD. CULTIVATION BETWEEN ROWS NEGLECTED.

PLANTATION ON THE STAKED PLAINS OF TEXAS, MADE ACCORDING TO PLANTING PLAN NO. 37.

they may be disregarded; three of the four farmsteads, however, are protected on all sides. The southwest and northeast quarters are laid out exactly alike, the purpose being to make each quarter section as nearly like each of the others as its position will allow. If all the farms of any region were laid out in accordance with this plan, there would be ample protection against the winds from any direction, since the plantations on adjacent sections would serve as windbreaks to their neighbors.

In laying out forest plantations for any farm the first thing to be done is to determine the location and size of the farmstead, and the number, size, and boundaries of the fields, with special reference to the application of a practical rotation of crops. The effectiveness of a windbreak is very largely dependent on the size and shape of the tract which it is designed to protect, and all forest plantations on agricultural land should be made subservient to the needs of agriculture.

In this plan the boundaries between fields have been placed in such positions that trees planted in the fence lines may, when grown, serve the double purpose of supporting wire fencing and protecting the crops from drying winds. All the windbreak belts except that along the south side of the northwest quarter are to be 81 feet 8 inches wide, allowing for a space of 9 feet 8 inches between the road fence line and the first row of trees. This permits the planting of 19, 17, or 13 rows of trees, at intervals of 4, 4½, or 6 feet. The space between the fence line and the first row of trees will permit the planting of a hedge and leave room to cultivate it, and will also allow room for the expansion of the crowns of a row of shade trees that may be planted 6 or 8 feet from the fence line along the public highway. Wherever the State laws are not prohibitive, it is very desirable that shade trees be planted along the public highways. This is quite possible in Oklahoma, since the public roads are generally surveyed and established 4 rods wide. Such road planting gives the whole country the general appearance of a cozy village. The side of each private lane next the open field is also to be planted with a single line of trees.

The fields of each quarter section are laid out with the same dimensions, so that uniformity in farm management will be perfectly feasible. They are also planned long and narrow, so as to be easily tilled and also well protected by the trees in the fence lines. The farmstead for each quarter is large enough to contain the buildings, orchard, feed lots, and barnyards, and is provided with ample shelter from sun and wind. The farmsteads are so located that no two will be opposite along the public roads.

The species recommended for the windbreaks provided in this plan and the best mixtures are given in diagrams 9 and 10. In

each instance intervals between the rows 4, 4½, and 6 feet are permissible. As a rule, the wider spacing with continued cultivation is advised, but in some cases it may be best to set the trees closer.

DIAGRAM 9.—*Mixture for a windbreak on high prairies with a dense clay subsoil.*

A M A M

L E L E

A M A M

L E L E

A=Green ash. M=Russian mulberry. L=Black locust or honey locust. E=White elm.

REQUIRED NUMBER OF TREES PER ACRE.

If planted in 19 rows 4 feet apart:	
Ash	716
Mulberry	716
Locust	644
Elm	644
Total	2,720
If planted in 17 rows 4½ feet apart:	
Ash	569
Mulberry	569
Locust	506
Elm	506
Total	2,150
If planted in 13 rows 6 feet apart:	
Ash	326
Mulberry	326
Locust	279
Elm	279
Total	1,210

For high prairies, where a windbreak to protect the farmstead from the north winds is desirable, alternating rows of red cedar and hackberry will serve the purpose admirably, if planted in accordance with the following diagram:

DIAGRAM 10.—*Mixture for a windbreak on a high prairie.*

H H H H

C C C C

H H H H

C C C C

H=Hackberry. C=Red cedar.

REQUIRED NUMBER OF TREES PER ACRE.

If planted in 19 rows, 4 feet apart:	
10 rows hackberry	1,432
9 rows red cedar	1,288
Total	2,720
If planted in 17 rows, 4½ feet apart:	
9 rows hackberry	1,138
8 rows red cedar	1,012
Total	2,150
If planted in 13 rows, 6 feet apart:	
7 rows hackberry	652
6 rows red cedar	558
Total	1,210

A good mixture suitable for either upland or bottomland consists of equal proportions of honey locust and green ash. These species may be planted in accordance with diagram 10 by substituting ash and locust for the hackberry and cedar. A still better method of mixing is to alternate the species in the rows according to the following diagram:

DIAGRAM 11.—*Mixture for upland or bottomland.*

A L A L

L A L A

A L A L

L A L A

A=Green ash. L=Honey locust.

REQUIRED NUMBER OF TREES PER ACRE.

If planted 4 feet apart in 19 rows:	
Green ash	1,360
Honey locust	1,360
Total	2,720
If planted 4½ feet apart in 17 rows:	
Green ash	1,075
Honey locust	1,075
Total	2,150
If planted 6 feet apart in 13 rows:	
Green ash	605
Honey locust	605
Total	1,210

A good mixture for fence posts consists of black locust and Osage orange planted 4 feet apart in rows 6 feet apart. At this rate of planting it will require 908 trees of each species to plant an acre. The wide spacing in one direction will permit of better cultivation

than if the spacing were closer and equal in both directions, while the close planting in the rows will allow a large number of trees per acre and consequently will be favorable to a high yield.

As stated on page 33, farms laid out according to this plan should have all the fence lines planted with shade trees, which can serve the double purpose of furnishing live fence posts and affording shelter and protection to the field crops. For single lines the trees should be planted from 20 to 30 feet apart. The best species for this purpose on the uplands of the region are hackberry, honey locust, white elm, and coffeetree. Black walnut may be used where the soil is not too dry. On bottomlands, cottonwood—the horticultural variety known as Carolina poplar—will grow most rapidly.

For protection against wind it is very desirable that the trees grow as tall as possible, since the distance at which a windbreak is effective is directly proportionate to its height.

MODEL PLANTING PLAN FOR THE PLAINS OF EASTERN NEW MEXICO AND WESTERN TEXAS.

The plains of eastern New Mexico and western Texas have a semiarid climate, the rainfall ranging from 12 to 20 inches per annum. Natural forest is almost entirely wanting, and artificial growth is made possible only by a careful selection of the planting site and the use of the most drought-resistant species. Land having an underflow within 15 feet of the surface without intervening rock may be suitable for the growth of forest trees.

Before planting an orchard on the plains it is necessary to provide a windbreak of forest trees on the south and west sides of the site. A windbreak on the north is advisable though not essential. In this section it is especially important to make the plantations in the early spring, in order that the trees may have time to establish themselves before the drying winds set in. It is best, however, to order the young trees for fall delivery, as spring shipments are likely to arrive too late for successful planting. As soon as they arrive they should be heeled in and cared for as described on page 13.

Fig. 7 shows practicable arrangements of windbreaks and other forest plantations for the farmstead on each of the four quarters of a section of flat land, every acre of which is tillable. Each planter will need to supply hedge rows and other windbreaks and to adapt and modify the plan to suit the conditions in his case. This plan differs from that proposed for the Cross Timbers or Red Beds Belts (fig. 6) in providing a woodlot as well as windbreaks for each quarter section. The primary utility of a windbreak is to shelter an orchard or a residence site or to prevent hot winds from scorching the field crops. Incidentally it may furnish valuable material, but in this region it must be established as a permanent feature of the

farm and be maintained for its influence rather than for its product of wood. A woodlot also may be so located that it will serve as a windbreak, but its primary purpose is the production of timber. These considerations require that windbreaks shall be placed where they will afford the most effective shelter without much reference to the character of the soil, while in locating a woodlot especial atten-

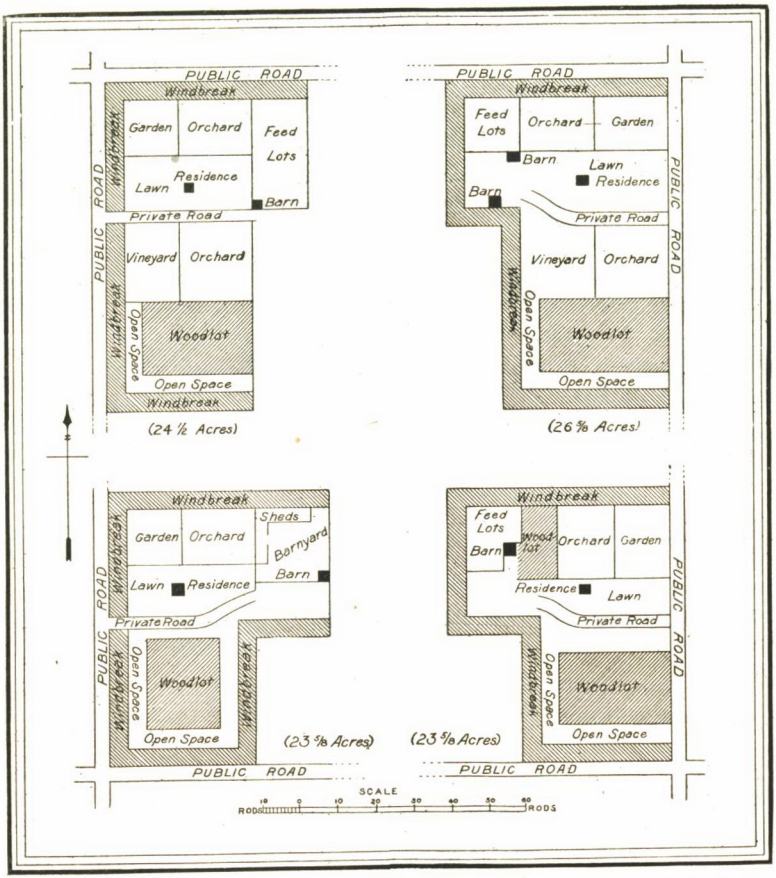

FIG. 7.—Model planting plan for the plains of eastern New Mexico and western Texas.

tion must be paid to the fitness of the site for the rapid production of desirable kinds of wood.

The number of species that can be recommended for planting on the semiarid plains is very limited, but any of the following may be planted with a reasonable prospect of success:

Green ash.
Red cedar.
Chinese arborvitæ.
Wild china.
Coffeetree.
White elm.
Hackberry.
Black locust.
Honey locust.
Russian mulberry.
Osage orange.
Western yellow pine.

The cottonwood will thrive in this region only where a constant supply of ground water is within reach of its roots.

It is generally believed that no kind of forest trees can be grown successfully on the high table-lands of this region without irrigation. There is no doubt that irrigation is necessary to grow trees from seed in a forest nursery, but in plantations good tillage will usually suffice. It is recommended that, where possible, the young trees be irrigated for several years until they have had time to develop full root systems, after which the water should be gradually withdrawn and the trees left to seek their own moisture. This method must be used with skill, as too much irrigation will cause the roots to grow near the surface of the ground, and will render the trees less able to endure drought than those grown without irrigation.

Each of the plans shown in fig. 7 makes an allowance for lawn, garden, orchard, and forest plantations of from 23 to 27 acres, which area is designated as the "farmstead." The areas devoted to forestry vary from 8 to 10 acres. Farmers when planning their residence lots are apt to grudge the land for gardens, lawns, and forest plantations, forgetting that the site is to be the home of the family, perhaps for several generations, and that a large part of the comfort and enjoyment of life is dependent upon the attractiveness of the farmstead.

The woodlots provided for each quarter section are separated from the windbreak belts by open spaces 5 rods wide, which are intended to be utilized for the growth of potatoes, melons, or similar crops. The trees adjacent to these strips will benefit by the cultivation and by the full exposure to light, which will cause them to grow more vigorously than trees in the interior of the forest plantations, and their fuller development will insure a more effective windbreak than would be obtained by planting in solid blocks.

The woodlots may be planted with pure black locust set 4 by 8 feet, but in order to secure a denser forest cover than the locust alone will afford it will be better to plant a mixture of black locust and Russian mulberry or Osage orange in equal proportions, according to diagram 12.

DIAGRAM 12.—*Mixture for a woodlot on semiarid plains.*

(Spacing 4′ by 8′.)

L X L X

X L X L

L X L X

X L X L

L=Black locust. X=Russian mulberry or Osage orange.

REQUIRED NUMBER OF TREES PER ACRE.

Black locust	680
Russian mulberry	680
Total	1,360

In addition to the windbreaks about the farmstead, trees should be planted in strips at least 2 rods wide running east and west across the farm, and separated by open fields not more than 80 rods wide. These will serve to protect the crops against hot winds. These windbreak belts should be laid out as follows:

The trees should be planted 4 feet apart in rows 8 feet apart. The first or inner row on the windward side of each field should be of honey locust, black locust, or cottonwood, according to the nature of the soil. Cottonwood should be used only on subirrigated land. Black locust will do best on moderately good soil and honey locust in the driest situations. All of these trees are rapid growers, and will soon give some shelter to the field. The main body of each windbreak should be planted with some of the following slower-growing, longer-lived species:

Green ash.
Coffeetree.
White elm.
Hackberry.
Wild china.
Black walnut.

Diagram 13 shows the arrangement of one of these windbreaks.

DIAGRAM 13.—*Mixture for a windbreak on semiarid plains.*

(Spacing 4′ by 8′.)

Y H Y H

A E A E

Y H Y H

A E A E

X X X X

FIELD.

X=Cottonwood, honey locust, or black locust. E=White elm. H=Hackberry. A=Green ash. Y=Wild china, coffeetree, or black walnut.

REQUIRED NUMBER OF TREES PER ACRE.

Single row of pure cottonwood, honey locust, or black locust	1,360
Mixture of—	
White elm	340
Hackberry	340
Green ash	340
Wild china	340
Total	1,360

TREES MENTIONED IN THIS REPORT.

Common name.	*Scientific name.*
Blue ash	Fraxinus quadrangulata.
Green ash	Fraxinus lanceolata.
White ash	Fraxinus americana.
Silver-bell tree (Bellwood)	Mohrodendron carolinum.
River birch	Betula nigra.
Cut-leaf white birch	Betula alba (form).
Hardy catalpa	Catalpa speciosa.
Red cedar	Juniperus virginiana.
Wild china	Sapindus marginata.
Choke cherry	Prunus virginiana.
Shittimwood	Bumelia lanuginosa.
Coffeetree	Gymnocladus dioicus.
Cottonwood	Populus deltoides.
Bald cypress	Taxodium distichum.
Deodar	Cedrus deodara.
Flowering dogwood	Cornus florida.
Slippery elm	Ulmus pubescens.
White elm	Ulmus americana.
Winged elm	Ulmus alata.
Gingko	Ginkgo biloba.
Red gum	Liquidambar styraciflua.
Hackberry	Celtis occidentalis
Hackberry (sugarberry)	Celtis mississippiensis.
English hawthorn	Crataegus oxyacantha.
Bitternut hickory	Hicoria minima.
Mockernut hickory	Hicoria alba.
Pignut hickory	Hicoria glabra.
Shagbark hickory	Hicoria ovata.
Hop hornbeam	Ostrya virginiana.
Locust	Robinia pseudacacia.
Honey locust	Gleditsia triacanthos.
Silver maple	Acer saccharinum.
Cut-leaf silver maple	Acer saccharinum (form).
Norway maple	Acer platanoides.
Sugar maple	Acer saccharum.
Red mulberry	Morus rubra.
Russian mulberry	Morus alba tatarica.
Bur oak	Quercus macrocarpa.
Pin oak	Quercus palustris.
Post oak	Quercus minor.
Red oak	Quercus rubra.
Scarlet oak	Quercus coccinea.

(Shin oak) Rocky Mt. oak	Quercus undulata.
Shingle oak	Quercus imbricaria.
Texan oak	Quercus texana.
Russian wild olive	Elaeagnus angustifolia.
Osage orange	Toxylon pomiferum.
Pecan	Hicoria pecan.
Persimmon	Diospyros virginiana.
Austrian pine	Pinus austriaca.
Scotch pine	Pinus sylvestris.
Western yellow pine	Pinus ponderosa.
Sassafras	Sassafras sassafras.
Black walnut	Juglans nigra.
Mexican walnut	Juglans rupestris.
Yellowwood	Cladrastis lutea.

SHRUBS USEFUL FOR PLANTING IN THIS REGION.

Common name.	*Scientific name.*
Althea	Hibiscus syriacus.
Azaleas	Azalea (species).
Flowering currants	Ribes aureum, etc.
Redtwig dogwoods	Cornus sericea, etc.
Forsythia	Forsythia (species).
Black haws	Viburnum (species).
Red haws	Cratægus (species).
Hoptree	Ptelea trifoliata.
Irish juniper	Juniperus communis hibernica.
Lilacs	Syringa vulgarus, etc.
Magnolias	Magnolia (species).
Dwarf maple	Acer glabrum.
Mock orange	Philadelphus coronarius.
Siberian peatree	Caragana arborescens.
California privet	Ligustrum ovalifolium.
Japan quince	Pyrus japonica.
Great rhododendron	Rhododendron maximum.
Native roses	Rosa setigera, etc.
Siberian rose	Rosa rugosa.
Spireas	Spiræa trifoliata, etc.
Tamarix	Tamarix amurensis.
Virginia creeper	Ampelopsis quinquefolia.
Waahoo	Evonymus atropurpureus.
Weigelia	Diervilla rosea.

INDEX.

Page.

Arbor vitæ, Chinese, use for tree planting, Texas and New Mexico 37
in mixture for tree planting 31
Arboretum, Henry Kendall College, Muscogee, Ind. T., note 21
Ash, green, use for planting, Texas and New Mexico 37
windbreak on semiarid plains 39
in planting mixture in Oklahoma 35
windbreak in Oklahoma 34
Bitter nut hickory, planting 17, 18
Biota orientalis. *See* Arbor vitæ.
Black locust. *See* Locust, black.
Black walnut. *See* Walnut, black.
Bottom lands, Lowlands Belt, Indian Territory, mixtures of trees for planting. 18, 19
Box elder, planting in Oklahoma, near Kingfisher 23
Carbon bisulphid, treatment of tree seeds for insects 14
Catalpa, planting and cultivation in Kansas 27
management at Stafford, Kans 25–26
in Lowlands Belt, Indian Territory 17, 18
Oklahoma, Red Beds Belt 27
use in forest plantation, Cross Timbers Belt, Oklahoma 24
Cattle, injury in tree plantations 12
Cedar, red, use for planting, Texas and New Mexico 37
in mixture in Oklahoma tree planting 31
windbreak in Oklahoma 34
Cherry, sour or Morello, use as windbreak 20
China, wild, planting on the plains 31, 37, 39
Chinese arbor vitæ. *See* Arbor vitæ.
Clay subsoil, windbreak, mixture of trees 34
Climate, Oklahoma, Roger Mills County 28
Coffee tree planting in Lowlands Belt, Indian Territory 17, 18
Oklahoma, Red Beds Belt 30
use for tree planting, Texas and New Mexico 37
windbreak on semiarid plains 39
Conifers, heeling in, care 13
Cooperation with farmers by Forest Service 7
Corn, injury to young trees 11
Cottonwood, growth in plains region, Texas and New Mexico 38, 39
planting in Oklahoma 31
Red Beds Belt 30
on sandy land in Kansas 28
Cross Timbers Belt, Oklahoma, planting plan 23–25
Cultivation, moisture conservation in plains region 38
objects and relation to forest planting 9
relation to water supply and season 10
tools and methods for tree plantations 11
Deciduous trees, planting 14
transplanting, size, etc 12, 13
Dunes, sand, Kansas, tree planting 25
Dust mulch, value in growing trees 9
Elm, white, planting in Indian Territory, note 21
use for tree planting, Texas and New Mexico 37
windbreak in Oklahoma 31, 34
on semiarid plains 39
Evergreen trees, size for transplanting 12
treatment in planting 15–16

	Page
Farm management, relation of forest planting	8
Farmers, cooperation with Forest Service in forest plantations	7
Fence posts, mixture of trees for planting	35
Fencing, wire, use of trees as support	33, 36
Field crops, injury to young trees	11
Fire, injury in tree plantations	11
Forest plantation, plan for Lowlands Belt, Indian Territory	16–19
Red Beds Belt, Kansas	25
plantations, cooperation of farmers and Forest Service	7
prairie and plain, care	9
Service, cooperation with farmers in forest plantations	7
Forests, factors controlling growth in the region	8
Grazing, injury in tree plantations	11
Green ash. *See* Ash, green.	
Hackberry, planting in Indian Territory, note	21
Oklahoma	31
use for tree planting, Texas and New Mexico	37
windbreak on semiarid plains	39
in windbreak in Oklahoma	34
Harrow, use in tree cultivation	9, 11
Heeling in, management of seedling trees	13
Henry Kendall College, planting plan	19
Hickory, bitter nut, planting in Lowlands Belt, Indian Territory	17, 18
Highways, usefulness of trees for shade	33
Horse power, use in planting trees	14–15
Indian Territory, Lowlands Belt, topography	16
Insects, larvæ, injury to tree seeds	14
Irrigation, need in plains region, Texas and New Mexico	38
Kansas, Stafford, commercial tree planting	25
Kingfisher, Okla., Cross Timbers Belt, planting plan	23
Locust, black or honey, use in windbreak in Oklahoma	34
use for tree planting, Texas and New Mexico	37
windbreak in Oklahoma	31
wood lot on semiarid plains	38
in forest plantation, Cross Timbers Belt, Oklahoma	24
honey, planting in Oklahoma, Red Beds Belt	30
use for tree planting, Texas and New Mexico	37
in planting mixture in Oklahoma	35
Lowlands Belt, Indian Territory, planting plan	16–19
Maple, silver, planting in Oklahoma, near Kingfisher	23
sugar, and Norway, planting in Indian Territory, note	21
Mariana plum, use for windbreak	20
Moisture, plains region, relation to tree growing	9
Morello cherry, use as windbreak	20
Mulberry, Russian, mixture for tree planting on sandy land	27
planting in Oklahoma	23, 24, 30, 34
use for tree planting, Texas and New Mexico	37
wood lot on semiarid plains	38
Mulch, value in growing trees	9–10
Muscogee, Ind. T., geological notes	19
Names, tree and shrub, lists	40–41
New Mexico, plains, planting plans for trees	36–39
Norway maple, planting in Oklahoma	21
Nursery, Henry Kendall College, species of trees	20
tree species from seed in Indian Territory	22
Oak, red, planting in Lowlands Belt, Indian Territory	17, 18
shin, or Rocky Mountain, thickets on Oklahoma sand hills	28–29
Oklahoma, Kingfisher, planting plan and topography	23
Red Beds Belt, prairie farm planting plan	31–36
Roger Mills County, climate, soil, water supply, etc	28
Orchard, wind-break on plains, need	36
Osage orange, hedge planting at Muscogee, Ind. T	20
planting in Oklahoma	31
use for tree planting, Texas and New Mexico	37, 38
in mixture for planting at Stafford, Kans	27
Ozark Mountains, forest, note	16

Page.
Pecan, planting in Lowlands Belt, Indian Territory 17, 18
Oklahoma, Red Beds Belt 30
Pine, western yellow, planting in Oklahoma 31
use for tree planting, Texas and New Mexico 37
Plains, forest plantations, care 9
western Texas and eastern New Mexico, planting plans 36–39
Plantations, forest, or prairie and plain 9–12
Planting plan, Cross Timbers Belt, Indian Territory 23–25
demonstration area, Indian Territory 19
for forest, requisites for making 7
Lowlands Belt, Oklahoma region 16–19
prairie farm, Oklahoma 31–36
Red Beds Belt, Kansas 25
Oklahoma 28
on plains of Texas and New Mexico 36–39
trees by horse power 14–15
proper season 12
Plowing, use in growing trees 9
Plum, wild and Mariana, use for windbreak 20
Prairie farm, Oklahoma, Red Beds Belt, planting plan 31–36
forest plantations, care 9
Kansas, near Stafford, tree planting 25
windbreak for clay subsoil 34
mixture of trees for Oklahoma 34
Precipitation, Lowlands Belt, Indian Territory, annual average 16
Muscogee, Indian Territory, annual average 20
Oklahoma, Roger Mills County 28
region, remarks 8
"Puddle," use in transplanting trees 13
Quercus undulata. *See* Oak.
Rainfall. *See* Precipitation.
Red cedar. *See* Cedar, red.
Red oak planting in Lowlands Belt, Indian Territory 17, 18
Rocky Mountain oak thickets in Oklahoma 28–29
Root, tap, relation to transplanting, note 23
Sand dunes, Kansas, tree planting 25
Sandy loam, Kansas, mixture of trees for planting 27
Sapwood, abundance, young trees 18
Season, tree-setting 12
Seed, deciduous tree, saving and planting 14
forest tree, source of supply, retail 24
Seedling trees, heeling-in 13
Semiarid plains, tree species recommended for planting 37
Setting out trees, proper season 12
Shade trees 36
planting in Indian Territory 21
use along highways 33
Shin oak thickets on Oklahoma sand hills 28–29
Shrubs for Oklahoma region, list, common and scientific names 41
species for arboretum, Indian Territory 22
Silver maple planting in Oklahoma 23
Soil, character in Oklahoma region, and treatment 9
Indian Territory, Muscogee, note 19
Oklahoma, Kingfisher, note 23
Roger Mills County, remarks 28
Sour cherry, use as windbreak 20
Spacing trees in forest plantation 10
Spring planting of trees, advantages 12
Sugar maple planting in Oklahoma 21
Stems, tree, care against injury in cultivation 11
Taproot, relation to transplanting of tree 23
Texas, western, planting plan for trees on plains 36–39
Tillage. *See* Cultivation.
Tools, kinds for use in tree cultivation 11
Topography, Indian Territory, Lowlands Belt 16
Oklahoma and adjacent regions 7
Kingfisher 23

Page.
Transplanting trees, details 12–13
Tree planting, cost, note 15
Trees, deciduous, planting 14
planting by horse power 14–15
mentioned in report, list, common and scientific names 40–41
numbers per acre in forest plantation 18, 19, 24, 27, 30, 34, 35, 39
setting out, proper season 12
spacing in forest plantation 10
species for Indian Territory arboretum 22
nursery from seed 22
recommended for Indian Territory nursery 20
with taproots not easily transplanted 23
stems, protection from injury 11
transplanting, details 13
proper size 12
young, heeling-in 13
injury by field crops 11
Walnut, black, mixture in tree planting at Stafford, Kans 26
planting and cultivation in Kansas 27
in Lowlands Belt, Indian Territory 17, 18
Oklahoma, Red Beds Belt 27
use for windbreak on semiarid plains 39
in forest plantations, Cross Timbers Belt, Oklahoma 24
Weather, relation to tree planting 13, 16
Weeds, destruction in cultivation of trees 9, 10, 11
White elm. *See* Elm.
Wild China, planting, Oklahoma, Texas, and New Mexico 31, 37
use for windbreak on semiarid plains 39
Wild plum, use for windbreak 20
Windbreak, Indian Territory, use of plum and cherry 20
semiarid plains, mixture for planting 39
trees for clay subsoil on prairie 34
use as support for wire fence 33
on plains, Texas and New Mexico 36
Windbreaks, Oklahoma Red Beds Belt, planting 30, 31
Roger Mills County, establishment 29
Winds, drying, protection of crops 33, 36, 39
Wood lot, provision in planting plan for Texas and New Mexico 36, 37
Wood lots, provision in plains, Texas and New Mexico 38

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